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COMPARATIVE STUDY ON ABRASIVE DEHUSKING OF PIGEONPEA AT ELEVATED MOISTURE

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ABSTRACT

A study was conducted to investigate the effect of moisture content, i.e., 10, 15, 20 and 25 (%, d.b.) on dehulling efficiency and *dal* recovery of pigeonpea. The milling of pretreated pigeonpea was done on abrasive dehuller and CIAE *dal* mill. The milling products were fractionated into unhusked whole grain, dehusked whole grain, unhusked *dal*, dehusked *dal*, broken and powder. The results were analyzed to find out the best level of moisture content for obtaining maximum percentage of finished product, *dal* recovery and highest hulling efficiency. The maximum dal recovery and hulling efficiency were obtained at 10% moisture content of pigeonpea grain and milled by using abrasive dehuller.

KEYWORDS: Pigeonpea, Milling, *dal* Recovery, Dehusking, Hulling Efficiency

INTRODUCTION

Pulses along with cereals play a vital role in human nutrition. Proteins present in pulses are complementary to cereal protein to make a balanced diet. For majority of vegetarian population of India, combination of cereals and pulses meets the nutritional requirements. Pulses are the second largest source of vegetable protein and cheapest among all protein sources. In India, about 80% of total pulse production is consumed in the form of *dal* or powder and remaining 20% as the whole seed and other forms (Chacko *et al*., 2001; Mangaraj *et al*. 2005). Whole pulses are milled into split *dal* by various methods. Generally, the husk is tightly attached to the cotyledons in pulses (Chakravarty 1988) due to presence of gum layer between seedcoat and cotyledons (Kurien and Parpia 1968). Depending upon thickness of gummy substances pulses are categorized into easy or difficult-to-mill kind of pulses. A pretreatment of pulse grain for loosening of the husk prior to milling is desirable as it increases the recovery of *dal*. Among these, the application of oil and water is most common at industrial level. Water soaking is prevalent for domestic scale milling. The recovery of *dal* varies from 60% to 75%, depending upon the type of pulses, method of pre-treatment and milling machinery used. Pigeonpea (Cajanus cajan), popularly known as *arhar* or *tur*, in Indian subcontinent, is the second most important pulse crop only after chickpea. Pigeonpea is primarily a crop of India, though it is grown in substantial areas of eastern Africa. Though pigeonpea is grown in a wide range of agro-ecological situations, its deep rooting and drought tolerant characters make it especially useful crop in the area of low and uncertain rainfall on the lighter soils. In northern India pigeonpea is main pulse crop, consumed daily. It is rich in iron, iodine and the essential amino-acids like lycine, cystine and arginine. Its straw is palatable and green leaves may be used as fodder. Sticks of pigeonpea are used for various purposes such as thatch roofing of mud houses and basket making. Pigeonpea being a leguminous plant is capable of fixing atmospheric nitrogen and thereby restores nitrogen the soil. Among all the pulses consumed in form of *dal*, pigeonpea is most difficult-to-mill because of thick gummy substance present in between seed coat and cotyledons (Sahay, 1991). Different pre-milling

treatments are prevalent in different parts of the country. Water soaking, sand roasting, oil and water, and thermal treatments are quite popular in the country. Water soaking ensures uniform treatment to individual grains and hence yields better finished product recovery. Whole grain is soaked for 6-8 hours, followed by sun drying to attain 10-12% moisture prior to milling. At commercial level milling is usually performed with the help of abrasive emery rollers. Dehusking at reduced moisture, result into powdering of precious cotyledons which gets mixed with husk. Efforts are being made to develop pre-treatments to dehusk the pulse with minimum damage to cotyledons.

The present study was undertaken to study the abrasive dehusking of pigeonpea at elevated moisture in lab and cottage scale mills.

MATERIALS AND METHODS

Pigeonpea grains procured from the grain store of Central Institute of Post Harvest Engineering and Technology, Ludhiana, Punjab was cleaned graded using cleaner-cum-grader. The cleaned pigeonpea seeds were soaked in water for 2 hrs. Moisture content was determined before and after soaking. After estimation of initial moisture content, the samples are kept in tray dryer at 55^0C for drying. The grains were kept in tray dryer and sample for milling were drawn when desired moisture levels of 10, 15, 20 and 25 (%,d.b.) were obtained. The samples drawn were kept in sealed flexible polybags.

Abrasive Dehuller

Dehulling was carried out in abrasive dehuller. Dehusking is done through abrasive disk in lab mills, which rotates inside sieve drum. Sieve separates powder fraction from milled grains. The samples were dehulled by maintaining constant abrasive wheel rotation and dehulling time of 15s. After dehulling unhusked whole grain, dehusked whole grain, unhusked *dal*, dehusked *dal*, broken and powder are obtained. Then the milled fractions are manually separated as unhulled, dehulled, and broken. All fractions were weighed and then expressed as a portion of the total original sample by weight.

CIAE *Dal* Mill

This is cottage scale mill, developed by Central Institute of Agricultural Engineering, Bhopal. Grain is fed through hopper, to be milled with the help of cylindrical emery roller, rotating in side perforated sieve drum in single pass. It is operated by 2 hp three phase motor and has the capacity of 100 kg/h. This machine was used for milling the pigeonpea at large quantities. The machine is a scaled downed model of commercial pulse dehusking unit. It provides larger surface area for dehusking in comparison to grain testing mill.

Dehulling Efficiency

The dehulling efficiency was determined using 150 g and 4.5 kg of cleaned and graded pigeonpea seed for different moisture levels (10%, 15%, 20% and 25%). From the outlet of dehuller, three replications of approximately 50 g representative sample was taken out and the different fractions, namely, unhusked whole seed, dehusked whole seed, unhusked *dal*, dehusked *dal*, broken, husk and powder were separated manually and the hulling efficiency was calculated using the formula suggested by Saxena (1985) and Saxena *et al.* (1990).

$$Dehulling\ efficiency = \left[1 - \frac{U_h}{T_h}\right]\left[\frac{F_p}{F_p + B_r + P_o}\right] X\ 100$$

Where, U_h - Weight of Unhusked grains obtained after milling

T_h - Weight of grains used for milling

F_p - Weight of finished product (Dehusked grain plus dal)

B_r - Weight of broken

P_o - Weight of powder

Dal Recovery

Dal recovery was calculated using the following formula;

$$Dal\ recovery = \frac{weight\ of\ dehusked\ whole\ grains + weight\ of\ dehusked\ dal}{weight\ of\ sample}\ x\ 100$$

RESULTS AND DISCUSSIONS

The present study was undertaken to explore possibility of using existing commercial abrasive roller devices for dehusking of pigeonpea at high moisture. At present dehusking at 10-12% moisture is common practice for commercial and domestic milling. Milling of dry grain mass leads to higher milling losses and precious cotyledons is lost in form of powder which gets mixed with husk. Usually this husk and cotyledon powder mixer goes for cattle feeding. To minimize milling losses high moisture abrasive milling was explored in this study. The milling fractions are obtained from abrasive dehuller and CIAE Dal mill were represented in table 1 and 2, respectively.

Table 1: Abrasive dehuller: Grain Testing Mill (%)

Moisture Content (%)	Milling						
	Milled Fractions (%)						
	Unhusked Whole Grain	Dehusked Whole Grain	Unhusked Dal	Dehusked Dal	Broken	Husk	Powder
10	2.9 ± 1.5	11.2 ± 1.5	2.9 ± 0.2	56.3 ± 1.6	4.4 ± 1.2	14.3 ± 1.0	8.0 ± 1.3
15	14.2 ± 2.2	19.6 ± 2.7	13.5 ± 1.4	26.1 ± 2.3	6.5 ± 1.3	10.6 ± 1.2	9.5 ± 1.0
20	44.2 ± 3.7	3.0 ± 0.9	31.0 ± 2.1	7.5 ± 1.9	2.9 ± 1.3	7.2 ± 1.0	4.2 ± 1.0
25	62.7 ± 3.3	1.7 ± 0.3	22.0 ± 1.8	5.0 ± 1.9	1.9 ± 0.2	4.0 ± 1.1	2.7 ± .01

Table 2: CIAE *Dal* Mill (%)

Moisture Content (%)	Milling						
	Milled Fractions (%)						
	Unhusked Whole Grain	Dehusked Whole Grain	Unhusked Dal	Dehusked Dal	Broken	Husk	Powder
10	31.8 ± 2.9	7.7 ± 1.6	1.6 ± 0.4	37.7 ± 1.2	4.6 ± 1.0	10.4 ± 1.9	6.2 ± 0.0
15	57.9 ± 0.9	8.4 ± 0.7	5.4 ± 0.6	15.7 ± 0.7	3.3 ± 0.6	5.5 ± 1.2	3.8 ± 0.0
20	90.8 ± 0.8	0.8 ± 0.4	3.4 ± 0.3	1.1 ± 0.2	0.5 ± 0.2	0.7 ± 0.2	2.7 ± 0.0
25	97.5 ± 0.3	0.2 ± 0.1	1.1 ± 0.1	0.4 ± 0.1	0.2 ± 0.1	0.3 ± 0.1	0.3 ± 0.0

Dehulling Efficiency

Dehulling efficiency is an indicator of percentage husk removal for the treated grain mass. The results thus obtained from abrasive dehuller and CIAE *Dal* Mill is tabulated in Figure 1. The results indicate that dehusking reduces

drastically with increase in moisture despite abrasive surface. Soft husk with high grain moisture is difficult to remove in comparison to brittle dry husk with abrasive surfaces. Different milled fractions obtained from CIAE *Dal* Mill were analyzed for dehulling efficiency. In case of CIAE *Dal* Mill the results were obtained for single pass. The material passes at higher moisture resulted into lower dehulling efficiency. This again indicates that at higher moisture content seed coat softens, making it difficult to remove using abrasive surface. Srivastava et al. (1988b) reported high dehusking efficiency when soaked in sodium bicarbonate (6%) solution. Saxena et al. (1981) suggested treatment of pigeonpea seed with sodium bicarbonate (0.3 to 1.0%). This resulted in the recovery of 68% *dal* and 88% dehusking efficiency.

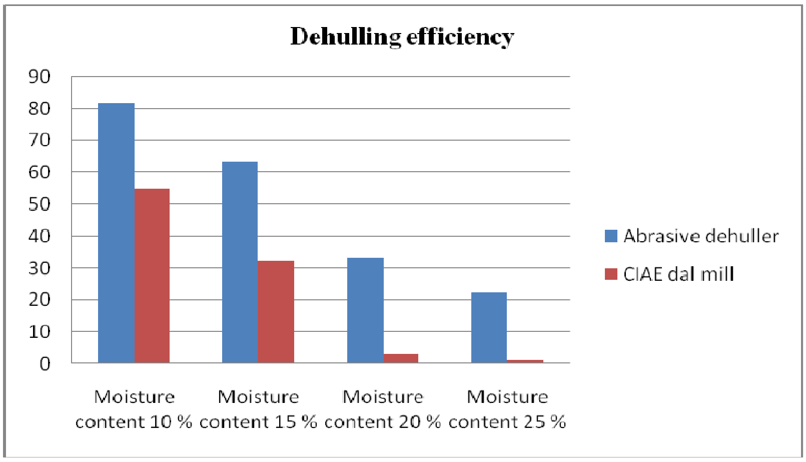

Figure 1: Dehusking Efficiency

***Dal* Recovery**

Dal recovery was calculated using equation 1. The results obtained from Abrasive dehuller and CIAE *Dal* Mill is shown in Figure 2. The figure explains that in grain testing mills maximum *dal* recovery of 67.3% was obtained at 10% grain moisture. With increase in moisture *dal* recovery reduces significantly. In single pass CIAE *Dal* Mill, gave maximum *dal* recovery of 45.40% at 10 % moisture. *Dal* recovery reduces drastically with increase in milling moisture of the grain. This indicates that even larger abrasive surface area showed no advantage in dehusking of high moisture pigeonpea grain. Since no control is provided in the machine to hold grain for longer duration, grain passes through the mill with least residence time. By providing outlet control dehusking time can be increased to study performance of emery roller on dehusking of high moisture grains. Reddy (1981) found 75% *dal* recovery and a 96% dehusking by pitting the seed followed by treatment with a sodium bicarbonate solution, tempering for 12 h, and oil treatment.

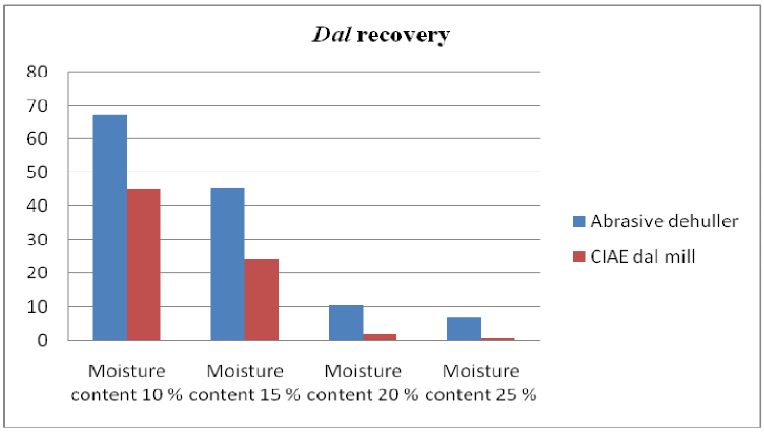

Figure 2: *Dal* Recovery

This indicates that soaking followed by drying to attain 10% moisture makes husk brittle which gets detached easily on application of shear force from emery rolls.

CONCLUSIONS

Pigeonpea is major pulse crop for Indian subcontinent. It is mostly consumed in the form of dehusked splits *i.e*., *dal*. Presence of thick gummy substances between seed coat and cotyledons makes dehusking of pigeonpea difficult. *Dal* yield of pigeonpea varies between 50 and 80 % in small-scale milling operations and between 60 and 85 % in large-scale milling operations (Singh and Jambunathan 1981). Various pre-treatments are given in different parts of the country to loosen the seed coat. Water soaking followed by sun drying and, oil and water treatments is prevalent throughout the country. Thermal treatment developed by CFTRI, Mysore and Sodium bi-carbonate treatment by GBPUAT, Pantnagar have found limited applications for milling of pigeonpea.

Usually pigeonpea is milled at 10-12% grain moisture in abrasive dehusking devices in several passes. CIAE, Bhopal *dal* mill is smaller unit of commercially used emery based abrasive rollers. Grain testing mill is also an abrasive surface device with smaller surface area and used for lab scale dehusking of grains. At low moistures about 15% precious cotyledons are lost in form of powder and get mixed with husk, and goes for cattle feeding. Efforts are on to reduce powdering losses. This study was initiated to study dehusking behaviour of pigeonpea in abrasive surfaces at elevated moisture. Pigeonpea grain after cleaning, grading, and destoning were soaked for 2 hours followed by tray drying at 55^0C. Samples with 25, 20, 15 and 10% were drawn from the drying lot. Milling was performed in grain testing mill for small samples of 150g and in CIAE Dal Mill for 4.5 kg samples. The study revealed high moisture dehusking is not possible with abrasive surfaces. Following conclusions can be drawn with the study:

- Abrasive surfaces efficiently remove brittle husk cuased by soaking followed by drying to reach 10% moisture.
- Moisture range around 10% is suited for abrasive dehusking of pigeonpea.
- At higher moistures though powdering reduces but *dal* recovery and dehulling efficiency reduces drastically.
- At higher moisture soft rubbing action may lead to better *dal* recovery with minimum breakage and powdering.

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